# Großflächige 24/7-Korrosionsüberwachung mit Geführten Wellen

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**Kurzfassung**

Die sich weltweit wandelnden Ansprüche fordern neue Lösungen für die Prüfung mechanischer Integrität. Das Gefährdungspotenzial und die möglichen Folgen eines unvorhergesehenen Wanddurchbruchs auf Grund von Korrosion, der zur Freisetzung von Kohlenwasserstoffen führt, ist mit das schlimmste Gefährdungsbild eines jeden Betreibers. Die ausschließliche Verwendung einer Risikobewertungen und interventionsbasierten Messungen, in Anbetracht zusätzlicher Erschwerung durch eingeschränkten Zugang zum Standort, aktuellen Reisebeschränkungen, hohen Einsatzkosten und Standortgefahren, reicht nicht aus, um Risikogebiete - insbesondere solche über oder in der Nähe von Gewässern – zu schützen.

In dieser Präsentation werden neu gewonnene Erkenntnisse aus der Kombination von hochgenauen Punktmessungen mit Rohrintegritätsüberwachung von langen Rohren mittels fest installierter Sensoren, besprochen. Dies bietet eine ständige Überwachung kritischer Bereiche und ermöglicht eine fundierte Planung präventiver Wartung, um die Gefahr der Freisetzung von Kohlenwasserstoffen zu minimieren. Es werden reale Anwendungen besprochen, die sich nicht nur auf die Detektion von Korrosion oder Erosion beschränken, sondern auch für die Optimierung von Anlagenprozessen von Bedeutung sind.

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# 24/7 large area corrosion monitoring

Thomas Vogt
May 2023

GULMONITORING

## Presentation Outline

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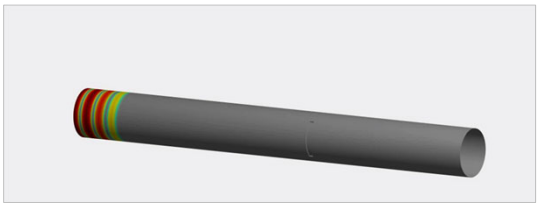
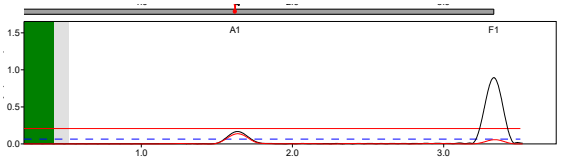
- Guided Wave SHM
- Why monitoring?
- Automated monitoring
- Example
- Combination with local monitoring

## Guided Wave Monitoring

- Structural Health Monitoring (SHM) systems takes advantage of permanently installed sensors to monitor for changes such as active corrosion or erosion.
- A volumetric method based on low-frequency guided waves for remote detection of localized damage anywhere within the pipe wall.
- Transmitted from a single sensor position, they propagate until reflected by a discontinuity and received with the same sensor.
- Only method sufficiently sensitive to provide practical large area coverage, i.e. using a single sensor, for structural health monitoring [Cawley, 2018].
- Other methods can only achieve coverage using many local sensors distributed over the area of interest.






Cawley, P., 2018, Structural health monitoring: Closing the gap between research and industrial deployment, *Structural Health Monitoring,* Vol. 17(5) 1225–1244.

## Why monitoring?

- Access to the pipe often accounts for a large fraction of the inspection cost and can have safety implications.
- Recurrent excavation for monitoring the pipe is costly and can carry risks.
- A permanent monitoring system reduces the impact of these factors as access only needs to be made once.
- Initial commercialization for repeat testing and scheduled monitoring (collection intervals of 1 – 5 years).
- Scheduled monitoring = comparison of data

## Scheduled GW monitoring

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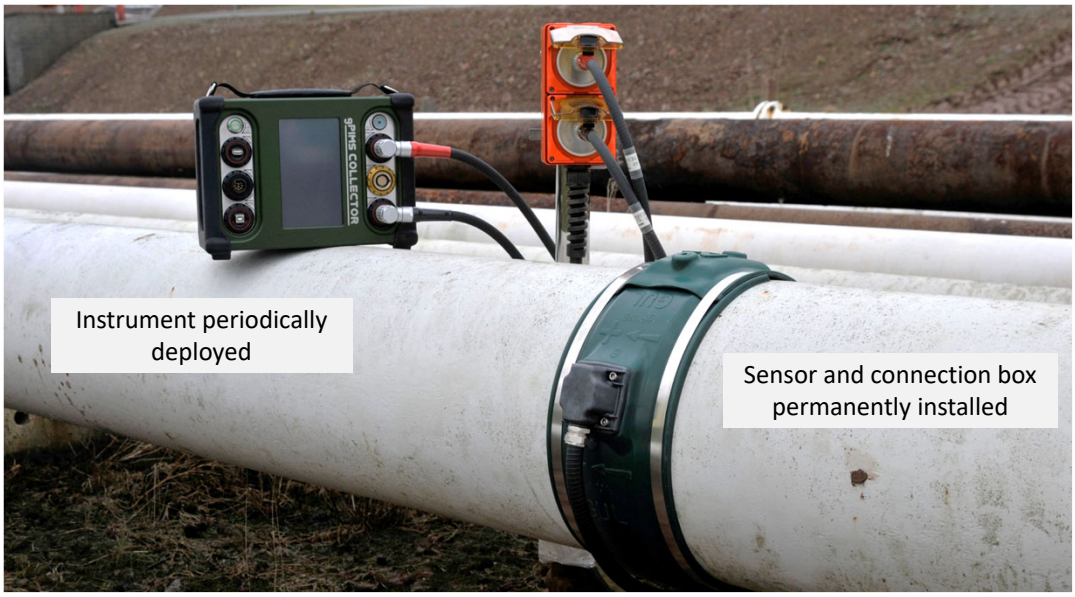


## Scheduled GW monitoring

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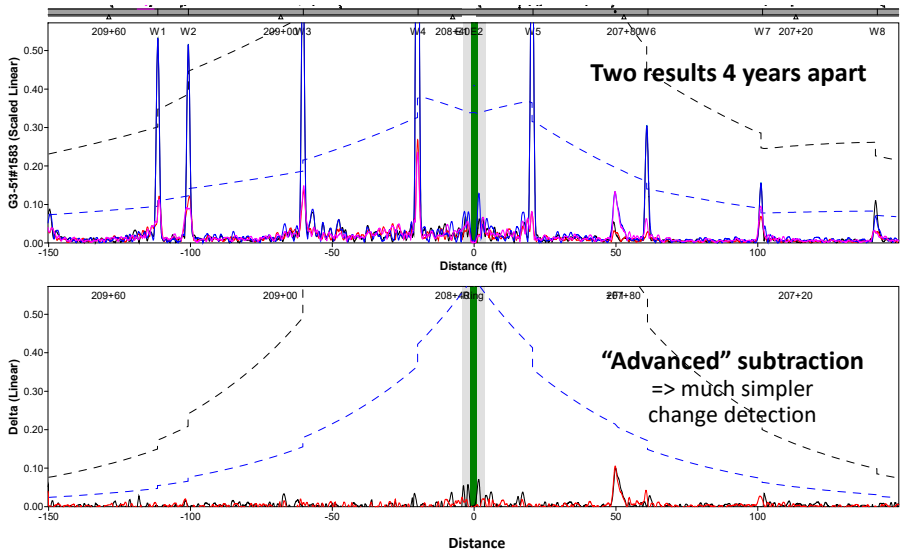

## Why monitoring - uncertainty in pipe condition

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Process conditions

Product composition

Abrasive solids

Inhibitor availability

Removing Uncertainty

## Why monitoring - safer operations

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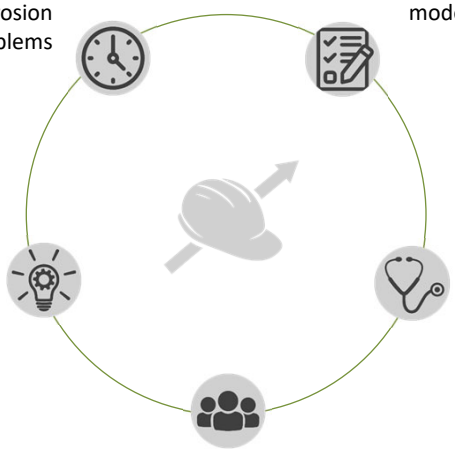
Earlier detection of pipe corrosion problems

Information stream for IM risk model

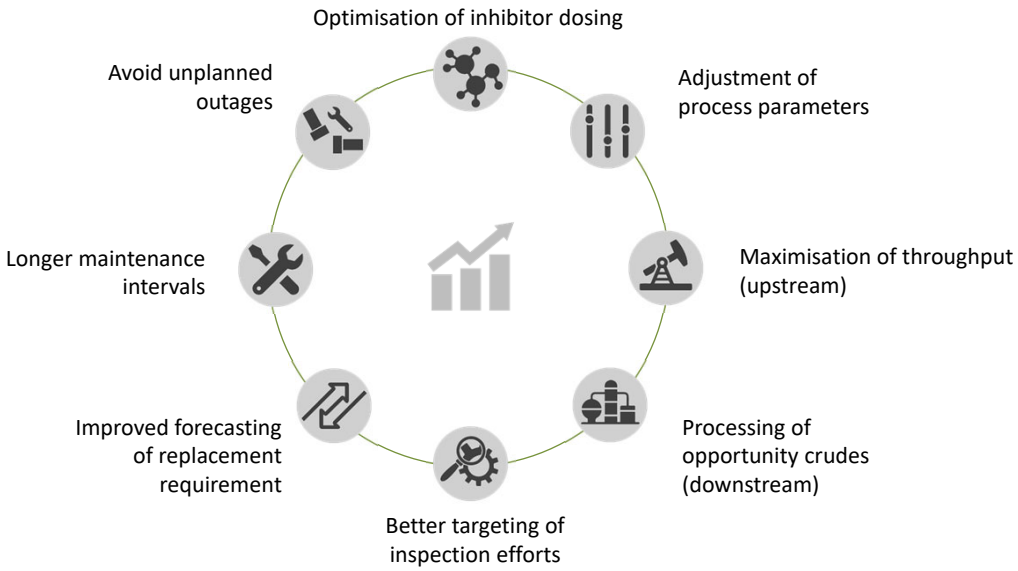


Improved understanding of causes of problems

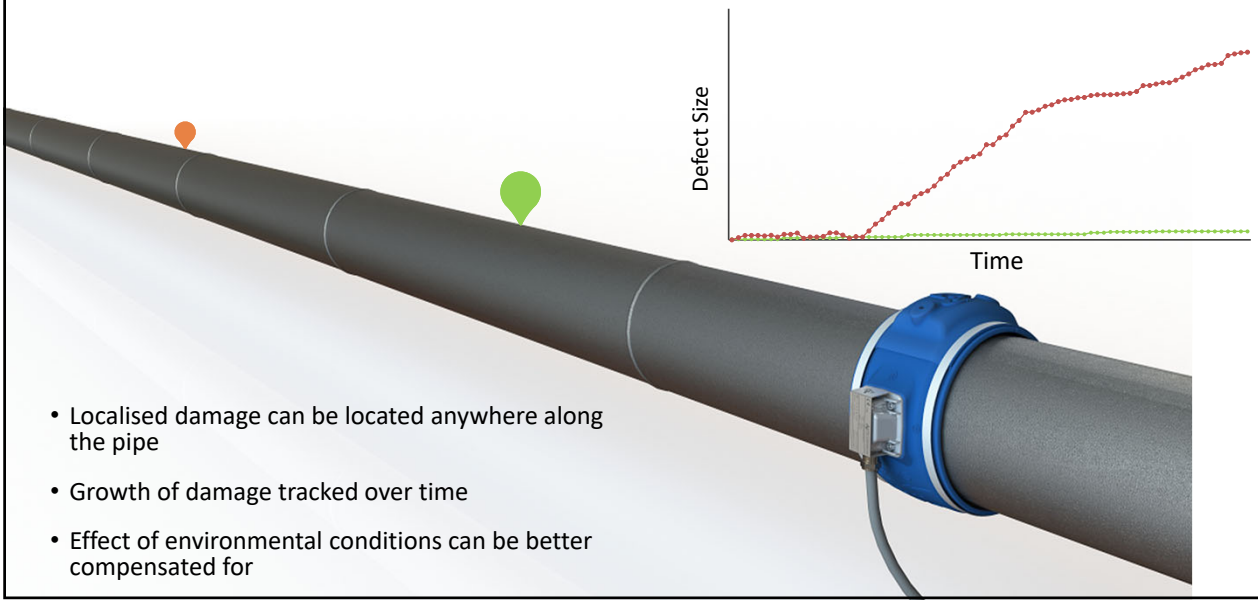
Monitor instead of emergency mitigation

Automatic systems reduce risk to personnel

## Why monitoring – increased profitability




## Automated GW monitoring

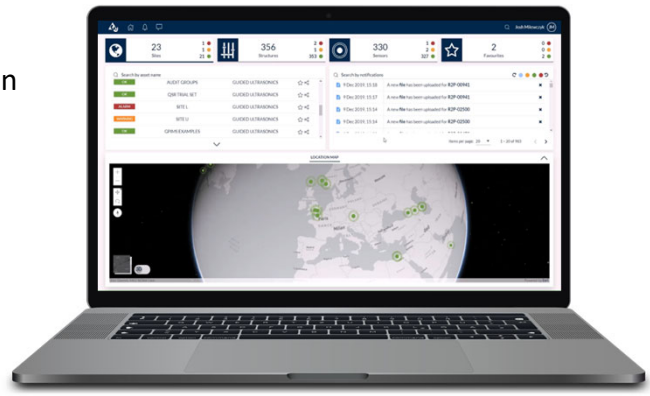


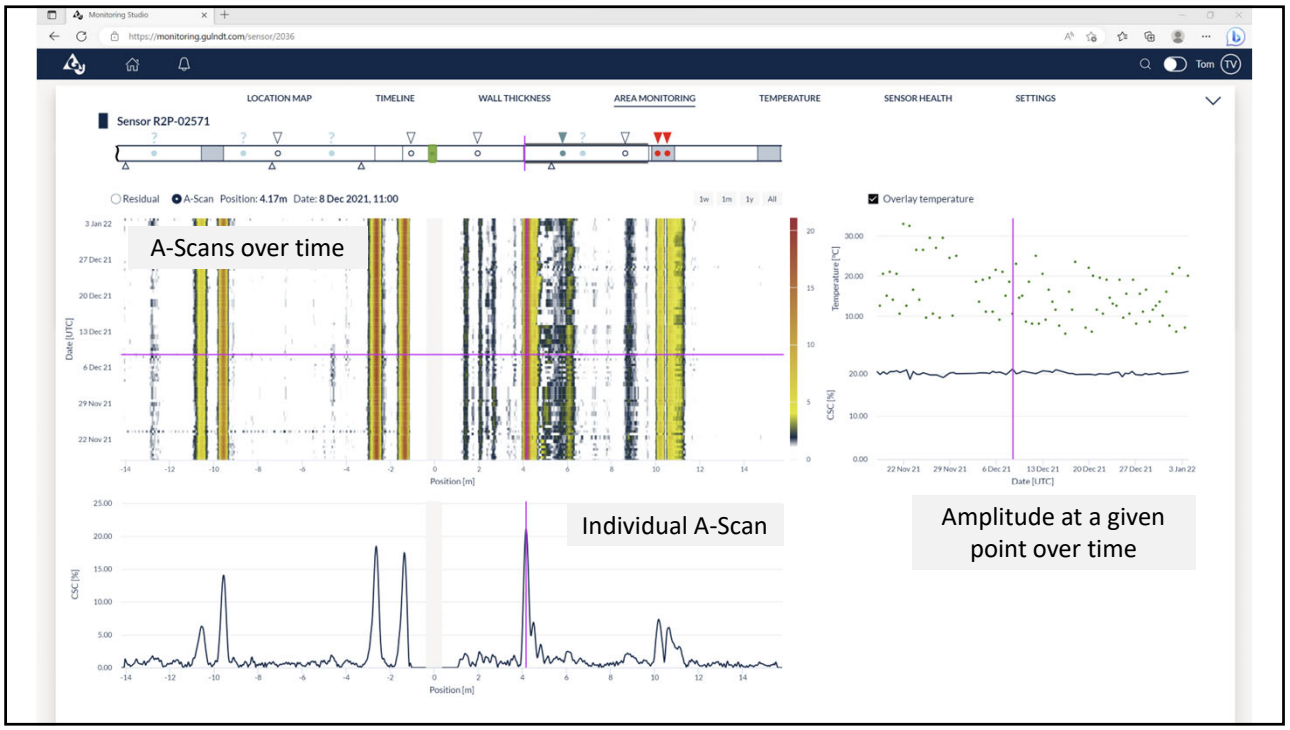

- Localised damage can be located anywhere along the pipe
- Growth of damage tracked over time
- Effect of environmental conditions can be better compensated for

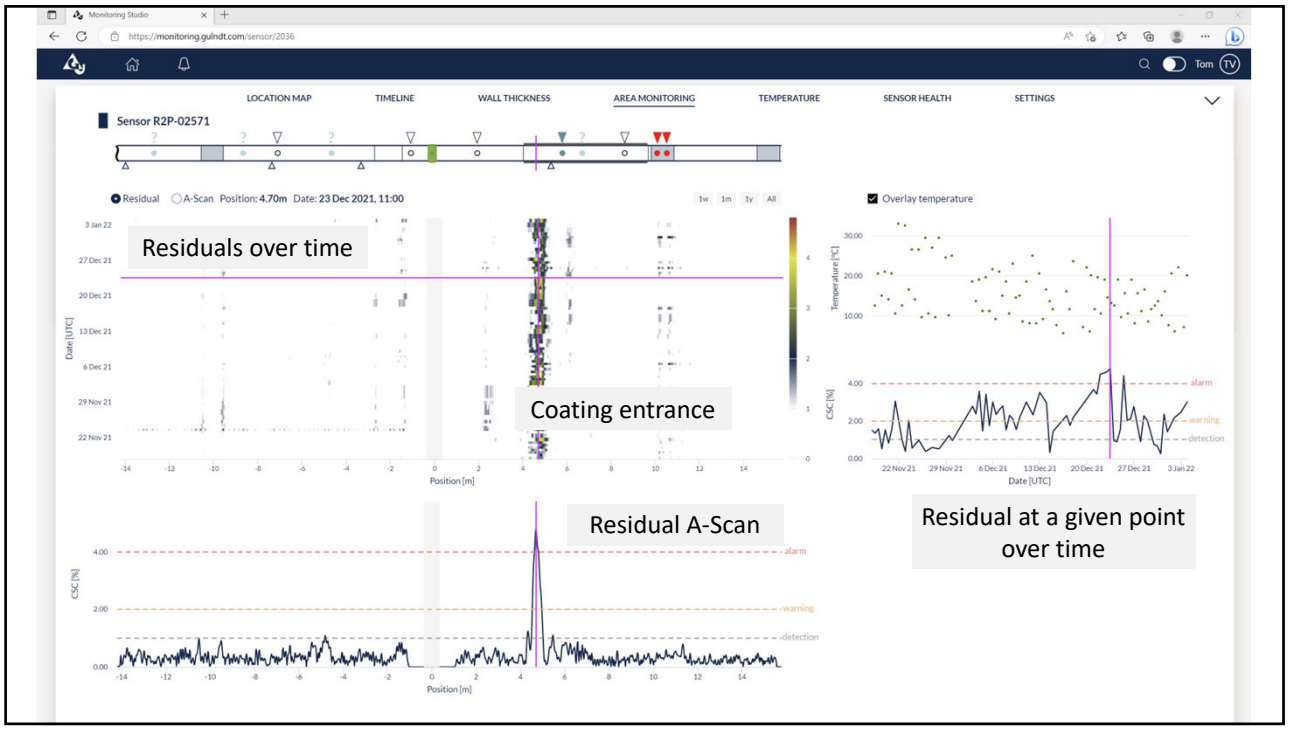
# Automated GW monitoring


# Automated GW monitoring

- Cloud-based data management SaaS
- Frequent data collection enables automation of processing and visualization of GW data
- Single source of truth data storage
- Meta-data storage for record keeping




Monitoring Studio
https://monitoring.gulndt.com/sensor/2036
Tom
LOCATION MAP
TIMELINE
WALL THICKNESS
AREA MONITORING
TEMPERATURE
SENSOR HEALTH
SETTINGS
Sensor R2P-02571
Residual
A-Scan
Position: 4.17m
Date: 8 Dec 2021, 11:00
1w
1m
1y
All
Overlay temperature
A-Scans over time
Date [UTC]
Position [m]
Temperature [°C]
CSC [%]
Individual A-Scan
Amplitude at a given point over time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LOCATION MAP
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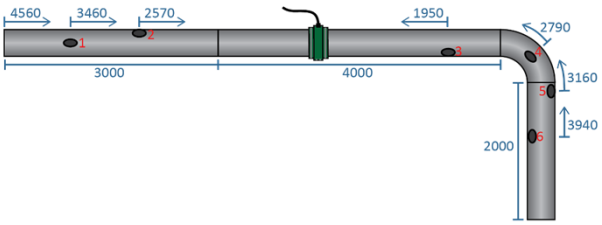
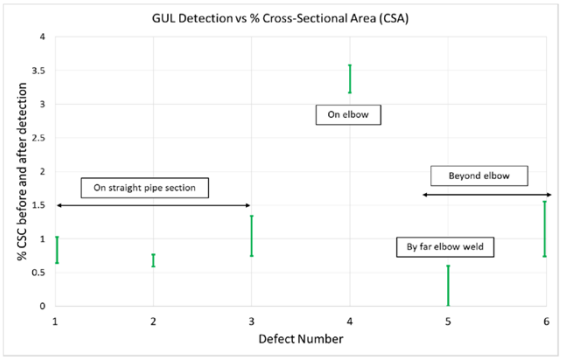
SENSOR HEALTH
SETTINGS
Sensor R2P-02571
Residual
A-Scan
Position: 4.70m
Date: 23 Dec 2021, 11:00
1w
1m
1y
All
Overlay temperature
Residuals over time
Coating entrance
Date [UTC]
Position [m]
Temperature [°C]
CSC [%]
alarm
warning
detection
Residual A-Scan
Residual at a given point over time

# Blind trial validation

- Independently run blind trial through the HOIS joint-industry project
- Temperature cycling between 13°C (55°F) and 40°C (104°F) throughout trial
- 6 defects introduced mechanically at unknown locations and starting times. All were detected.
- 5 defects detected in the 0.5 to 1.0% CSC range
- Defect 4 detected later due to bend effects

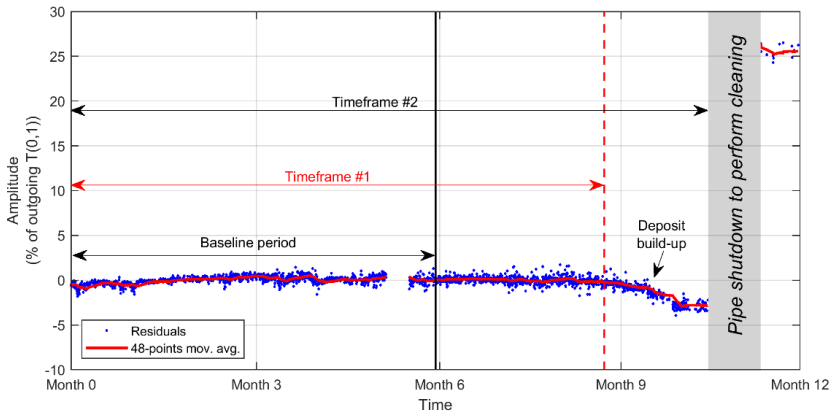



Heinlein et al., 2018, Blind Trial Validation of a Guided Wave Structural Health Monitoring System for Pipework, *Materials Evaluation*, Vol: 76

# Application example

- Flare gas line prone to deposit build up
- Amplitude of a weld monitored over time
- Allows tracking of deposit build up and efficient management of cleaning operations




# Automated “Small area” GW Monitoring

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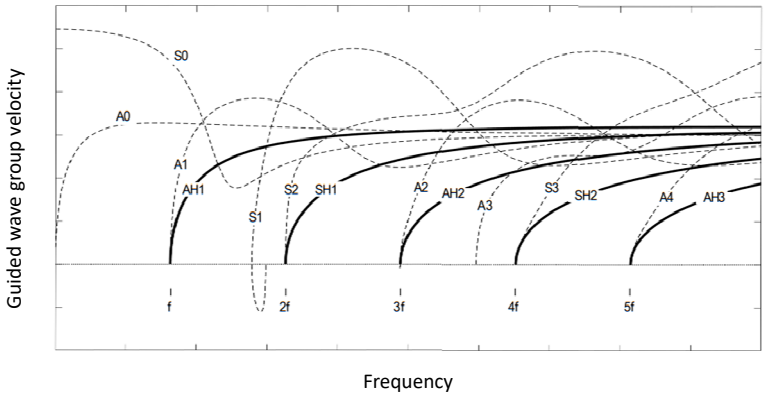
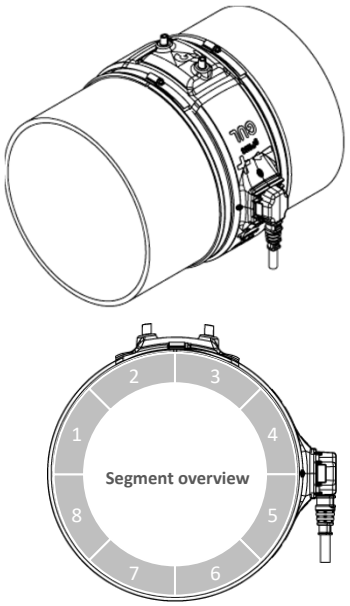
- GW used for large area monitoring not suitable for **uniform** wall loss along the pipe
- Measurement of pipe wall thickness around circumference based on GW cut-off modes implemented in the sensor





# Automated “Small area” GW Monitoring

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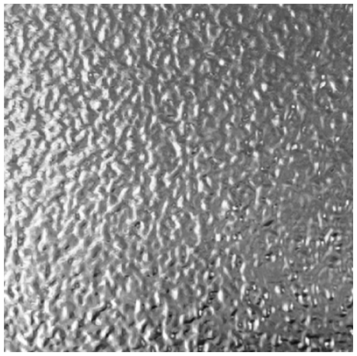
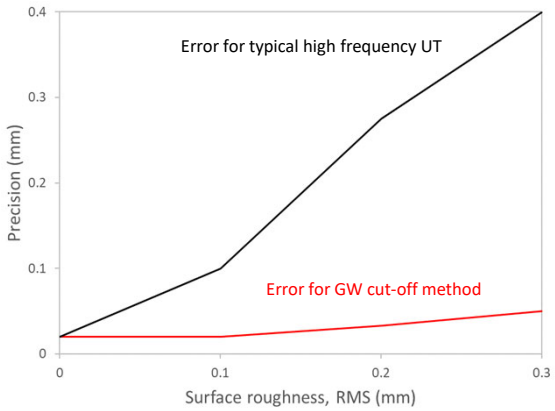
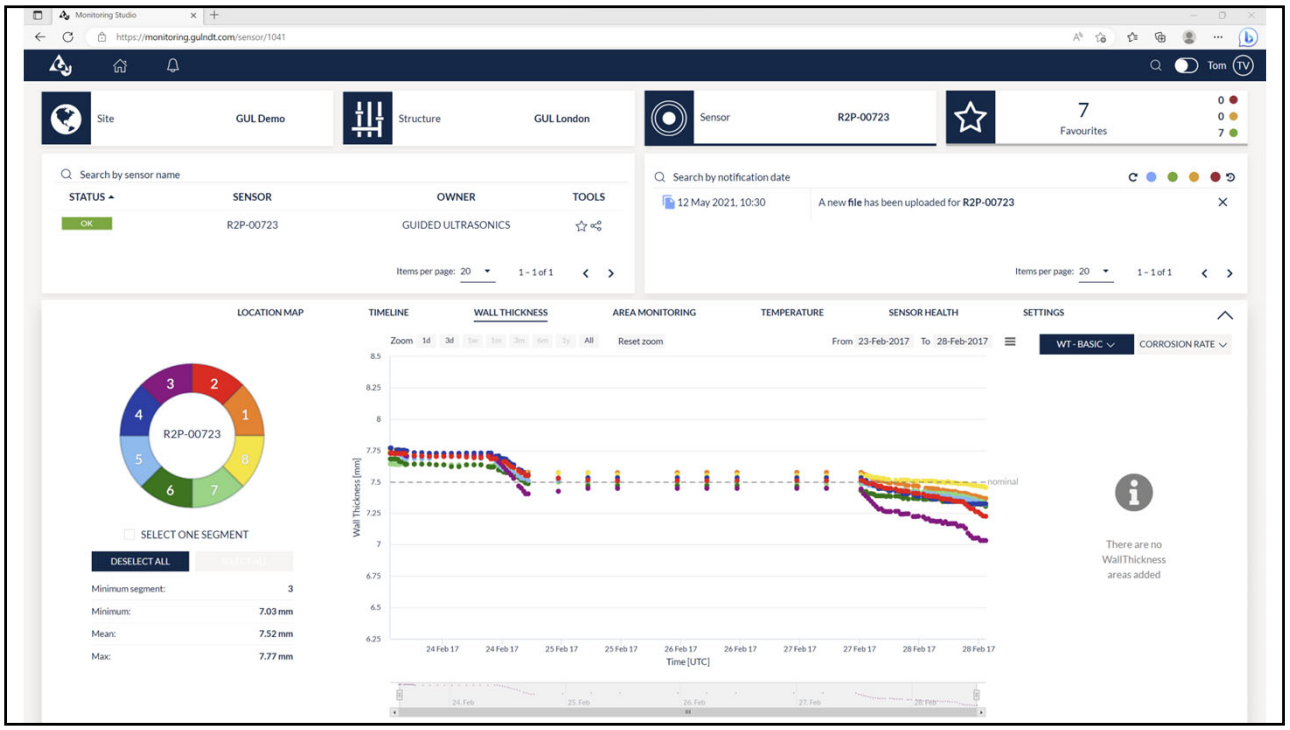
- Lower frequency than conventional thickness measurement
- Much less affected by surface roughness than conventional UT monitoring



Typical surface with 0.3mm RMS roughness




Heinlein et al., Improved thickness measurement on rough surfaces by using guided wave cut-off frequency, NDT & E International, Volume 132, 2022, 102713




## Guided Wave Monitoring - Summary

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- Large and small area monitoring can supplement and enhance existing corrosion monitoring programs with autonomous and intuitive data reporting.
- Large area monitoring for localized damage detection and trending
- Small area wall thickness monitoring for detection of uniform damage mechanisms. Tolerant of rough surfaces developing during corrosion/erosion growth.
- Technology sensitive to a large range of damage mechanisms (internal and external corrosion, erosion) and other operational parameters of interest.
- Real-time pipe condition status through cloud-based infrastructure that automatically collects, transmits, processes and visualizes results, accessible anywhere.

# Technology you can trust.



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